International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 1, December 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Analysis of the Characteristic behaviour of Concrete with Rice Husk Ash and Sugarcane Bagasse Ash

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ABSTRACT

In the last decades, the use of residue in construction industry, especially as additives in concrete, has been subject of many researches as it may lead several improvements in the concrete properties, besides reducing the environmental pollution. The world rice harvest is estimated in 600 million tons per year. In terms of production sugarcane tops the crop ranking order. In India alone there grows 352 million tons of sugarcane and processed by 138 sugar mills. Considering that 22% of the grain is husk. So both the rice husk and sugarcane bagasse ash are complete waste and can be used as substitutes in concrete. The RHA and Sugarcane bagasse ash were trialed to replace concrete with various ratios of RHA (0%, 10%, 20%, 30% & 40%) with fine aggregates and SCBA (0%, 5%, 10%, 15% & 20%) with cement. The water/cement ratio in all the mixes was maintained at 0.55. From the experimentations it was inferred the modified specimen resulted in number of improvement of properties of cement. The observed increase in compressive strength of concrete is maximum, when the conventional concrete is modified with 15% SCBA and 30% RHA. With this percentage modification there seen increase in both 28 as well as 7 days compressive strength. There observed considerable reduction in slump value yet keeping the mix workable or in other words we can say that modification of concrete by SCBA and RHA do not adversely affect the workability. The 28-day split tensile strength test revealed that the inferences of compressive strength test and split tensile strength were somehow similar to one another. More the application of SCBA and RHA, lesser are their disposal problems and thus results in reduction of carbon credits by these waste products. This research promoted an ecological way of waste management and sustainable construction.

KEYWORD: SCBA, RHA, Sugarcane, Bagasse, Compressive Strength

How to cite this paper: Sultan Singh | Er. Sunil Kumar | Er. Vikram "Analysis of the Characteristic behaviour of Concrete with Rice Husk Ash and Sugarcane Bagasse Ash" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-1, December 2019, pp.930-935, URL: www.ijtsrd.com/papers/ijtsrd29774.pdf

IJTSRD29774

1. INRODUCTION

SCBA is a major waste produced in our country and even in Haryana alone there are ten sugar mills which crush about 22.6 million tons of sugarcane per year. The sugarcane bagasse ash comprises hemicelluloses, lignin and cellulose infractions 25%, 25% and 50% respectively. A major part of the bagasse ash thus developed is utilized as a fuel in boilers, distilleries and small amount for power generation in sugar factories. After removing sap from sugarcane, its dry bagasse is burnt to obtain bagasse ash. This burning is carried out at controlled condition, so that the product obtained have high SiO_2 content and can serve as ingredient of concrete. This SCBA can supplements concrete as cement substitute which not only lessens the carbon credit and load of cement industry but also enhances its strength in compression. SCBA is an inert material and does not cause any harmful chemical effect but strengthens physical properties of modified concrete. The physical features such as texture, filler effect and size etc. are improved in all aspects. SCBA has pozzolonic nature. India seconds the ranking order in terms of population round the globe. With increase in population consumption of products too increases. Higher the consumption more is the waste generated. The only means of disposal of these industrial, agricultural and household wastes generated are incineration or disposal in water bodies. This results in contamination of water bodies. So, REUSE is the only option for eradicating this problem as it is growing severe day by day. For sustainable development eradication of this issue is obligatory. Usage of concrete is not just limited to building construction but has a far reaching span from bridges, airports to skyscrapers, thus, remained a consistent topic of civil engineering explorations till date. With prompt population explosion there is a dying need of constructing habitats for the growing population, which can only be quenched by strong and durable concrete.

2. LITERATURE REVIEW

Mehta and Pirtz (2018) concluded through their study that the ash produced by burning hulls of rice is highly reactive and rich in silica, which found its successful application in mass concreting operations. This ash reduces the quantum of heat produced. Due to exceptionally high surface area of the ash, the concrete containing RHA showed only 13mm slump as compared to 95mm slump for control concrete.

Md. Abdullah Al Mamun (2017) examined early age strength variation of cement by substitution of cement by RHA in different fractions. The fractions used by wt. were 0% to 15%. He carried out a high order research work by using high performance concrete. The experimentations were carried out in both laboratories as well as in field, so that real time behavior was diagnosed efficiently. Outcomes were quite remarkable in which more controlled mix can be developed by this technique. Setting time was substantially reduced but percentage replacement can be raised without harming properties of concrete. Great results were obtained by working out results of strength in compression. Not only this but also reduced porosity and made the mix impermeable, improved penetration depth and reduced the quantity of cement to be used.

M. B. Prajapati (2016) carried out experimentation for validation of RHA as a partial substitute of cement. Not only this but also he used a little content of Steel fiber too with RHA. The experimental investigations were performed on M30 concrete with varying proportion of RHA as well as steel fiber. He carried out test for 7; 28 as well as 56 days.

3. MATERIAL & EXPERIMENTATIONS

Properties of Material used

The important ingredients used in preparing concrete mix are discussed and detailed below with their important characteristic properties. These properties allow the engineer to opt the correct material for right situation and suitability

Cement

Cement is a key component of concrete and in technical terms it is a calcareous or siliceous crystalline compound which is featured with special hydraulic properties. The four key compounds necessary for production of cement are termed as Bogue's Compounds and these are namely C3S or Tri-calcium silicate, Tetra calcium alumino ferrite (C4AF), C2S or Di-calcium silicate, Tri-calcium aluminate (C3A), where Calcium oxide is abbreviated by C, S stands for silica (SiO2), A stands for Aluminum oxide (Al2O3) and F for Ferric Oxide (Fe2O3). Out of these four compounds C3S and C2S are the compounds which are the major constituents (about 70%) and also significant strength contributors to the cement.

Coarse aggregates

The aggregates with size greater 4.75 mm are termed as Coarse aggregates. These aggregates retain on 4.75 mm sieve. There are different sorts of coarse aggregates available in market, namely:

- Uncrushed Stone or Gravel: These are bigger size coarse aggregates and formed due to natural degeneration of rock.
- Crushed Stone or Gravel: These are finer than uncrushed gravel and formed by their decomposition.
- Partially Crushed Stone or Gravel: These are formed by blending Uncrushed and Crushed Stone or Gravel together.

Fine aggregates

The aggregates with size less than 4.75 mm are termed as Fine aggregates. These aggregates pass through 4.75 mm sieve. There are different sorts of fine aggregates available in market, namely:

- Natural Sand: These are deposited at river banks or entrapped in glaciers and formed due to natural degeneration of rock.
- Crushed Stone Sand: These are finer aggregates and formed by decomposition of hard stone.
- Crushed Gravel Sand: These are formed by crushing of natural gravel

Workability of concrete

In simpler words the dexterity of working with green concrete is termed as "Workability" and in technical terms it is that property of fresh concrete or mortar which governs the ease and evenness with which it can be mixed, placed, compacted, and finished. Workability is not merely a characteristic of the concrete, rather it a major property that govern the nature of the application of concrete mix. The durability (or life) and strength of hardened concrete in turn depends on it. Different test methods are opted to check the workability. Some of the tests commonly used in field as well as laboratory to find workability are:-

- Slump Test
- Compacting Factor Test
- Vee-Bee Test
- Flow Table Test

Compressive strength of concrete

Before testing the quantities of various ingredients and modifiers like cement, coarse aggregates (20 mm and 10 mm), fine aggregates, SCBA, RHA and water were weighed and jotted down separately. Firstly, the properly graded SCBA and cement were blended uniformly in dry state. Then to this dry mix fine aggregates and RHA were also mixed properly in requisite proportions. After that coarse aggregates were added uniformly to give rigid skeleton to the mix.

Flexural Strength test

To find flexural tensile strength of concrete, beam of dimensions (100 x 100 x 500 mm) are prepared. Then the sample is tested using Universal Testing machine with 3 point load at a loading rate of 180Kg/min. up to failure.

Flexural strength= $\frac{PL}{bd^2}$

4. RESULTS

Designation of Concrete mix:

Strength of specimen in Compression was calculated by testing cubical specimen each of edge 150 mm. This cubical specimen was casted in a mould which greases its sides from oil before pouring the concrete. The varying proportions of modifier and designation of the mix are tabulated in the successive table.

Designation of concrete mixture

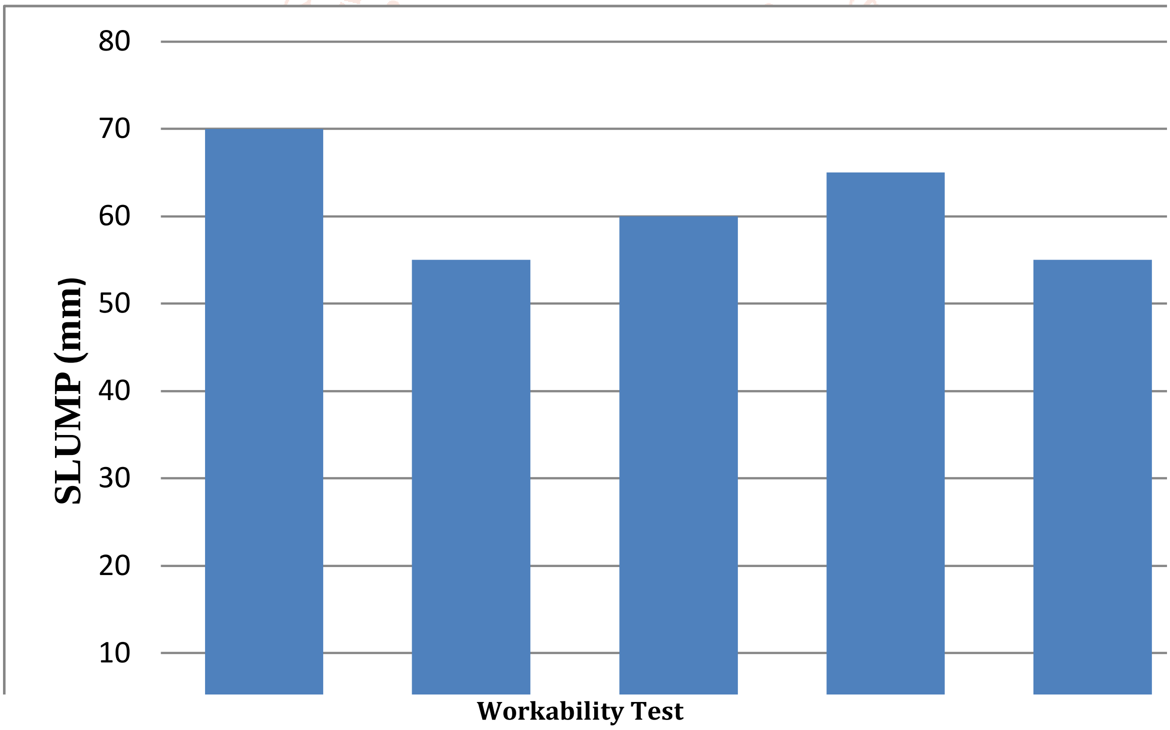
Mix	RHA (%)	SCBA (%)	Cement (%)
S1		0	100
S2		5	95
S3	0	10	90
S4		15	85
S5		20	80

S6	10	0	90
S7		5	85
S8		10	80
S9		15	75
S10		20	70
S11	20	0	80
S12		5	75
S13		10	70
S14		15	65
S15		20	60
S16	30	0	70
S17		5	65
S18		10	60
S19		15	55
S20		20	50
S21	40	0	60
S22		5	55
S23		10	50
S24		15	45
S25		20	40

Test for Workability of concrete:

Results of workability test of concrete

Specimen	SCBA (%)	RHA (%)	Slump (in mm)
S0	0	0	70
S1	5	10	55
S2	10	20	60
S3	15	30	65
S4	20	40	55



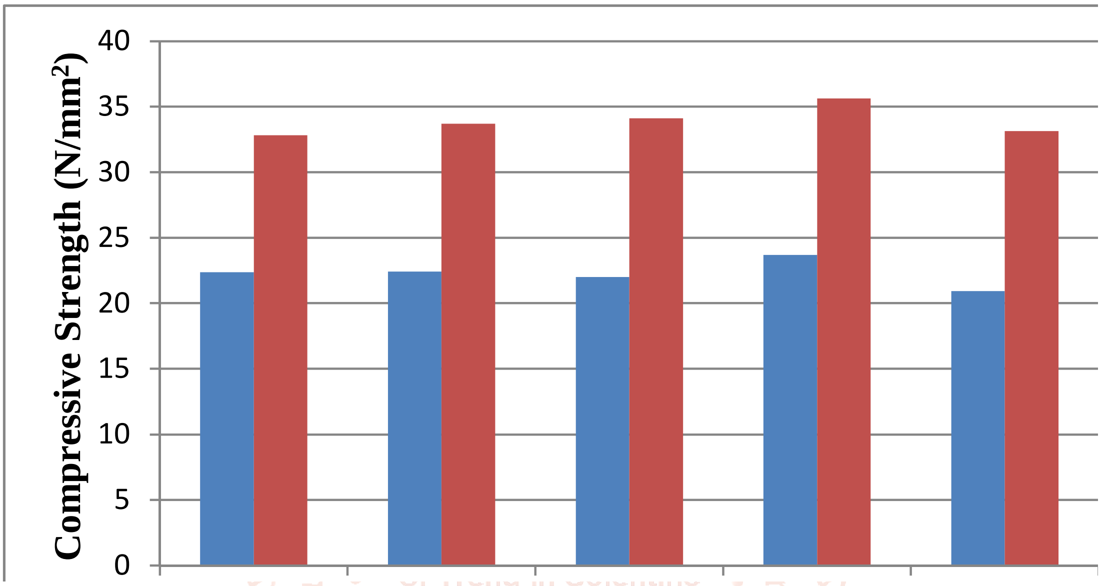
Test for Compressive Strength:

Results of test carried out on different specimens for Compressive strength are tabulated as below:

Test results for compressive strength

Mix	SCBA (%)	RHA (%)	$f_{ck,avg}$ (N/mm²)			
			7 days	Mean Value	28 days	Mean Value
S0	0	0	22.01	22.37	32.70	32.80
S1			22.63		32.90	
S2			23.06		32.80	

S3			21.87		33.10	
S4	5	10	22.51	22.44	33.17	33.68
S5			22.92		34.79	
S6			21.43		34.55	
S7	10	20	22.05	22.00	33.59	34.11
S8			23.53		34.19	
S9			23.90		35.79	
S10	15	30	23.80	23.70	35.83	35.61
S11			23.70		35.21	
S12			20.14		33.80	
S13	20	40	20.79	20.91	32.84	33.14
S14			22.23		32.79	



Compressive Strength Test

Split Tensile Test

Results of test carried out on different specimens for split tensile strength are tabulated as below:

Split tensile test

Sample	Split Tensile strength in MPa
S0	2.80
S1	2.86
S2	2.93
S3	3.97
S4	3.04

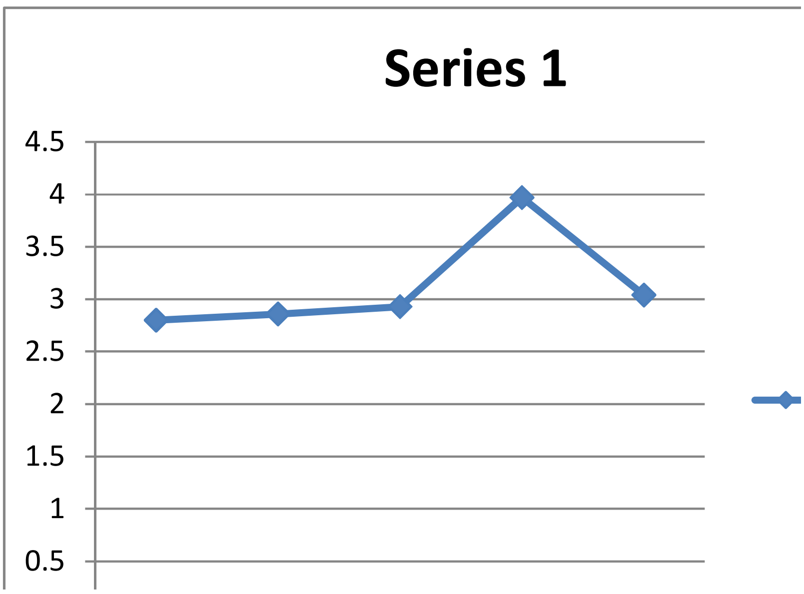


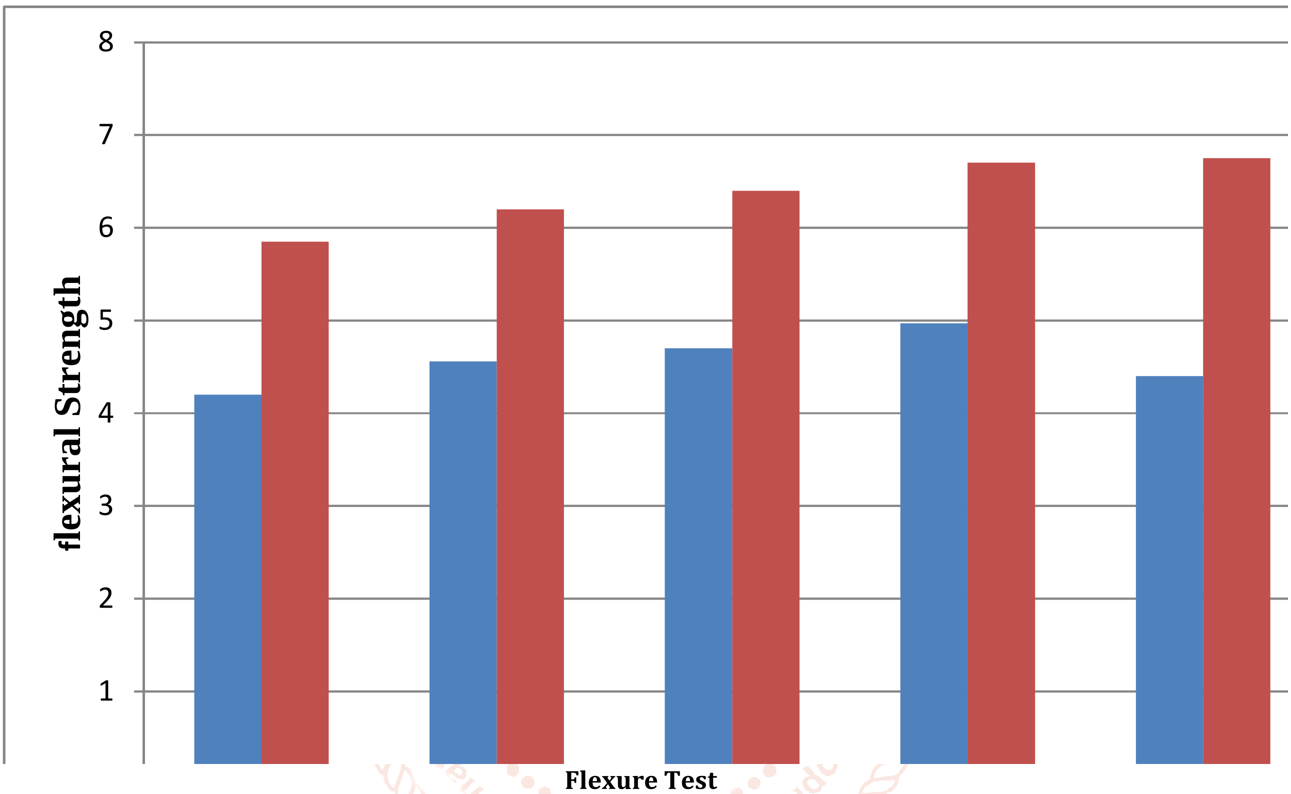
Fig. 4.3 Split Tensile Test

Test for Strength in Flexure

Results of test carried out on different samples for flexural strength are tabulated as below: Flexural Strength (F.S.)

Flexural Strength Test

Sample	7 Days	28 Days
S0	4.20	5.85
S1	4.56	6.20
S2	4.70	6.40
S3	4.97	6.70
S4	4.40	6.75



5. Conclusion

In this chapter, the whole research is concluded with all its major pros and cons. From the experimentations carried in the previous chapter it was inferred the modified specimen resulted in number of improvement of properties of cement.

The conclusions drawn are briefed as below:

A. Observations drawn from compressive strength test showed that the observed increase in compressive strength of concrete is maximum when the conventional concrete is modified with 15% SCBA and 30% RHA.

B. With this percentage modification there seen increase in both 28 as well as 7 days compressive strength.

C. The modified sample had not any considerable effect on 7 day flexural strength but improved 28 days flexural strength to a promising value.

D. There observed considerable reduction in slump value yet keeping the mix workable or in other words we can say that modification of concrete by SCBA and RHA do not adversely affect the workability.

E. The 28-day split tensile strength was conducted on different concrete mixes under different restraints and conditions. From the results it was inferred that the inferences of compressive strength test and split tensile strength were somehow similar to one another.

F. More the application of SCBA and RHA lesser be their disposal problems and thus results in reduction of carbon credits by these waste products.

G. This research promoted an ecological way of waste management. Yet both RHA and SCBA are bio-degradable waste but need ample time for their decomposition. Meanwhile, serve as rotten or disease causing waste product.

H. Not only improvement in engineering properties of concrete this is an economical as well as ecological modification of concrete. As the SCBA and RHA are complete waste and of not use but can be used as modifier in concrete and they are available at cheaper rates.

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